GUIDELINE A-7

Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators

Legislative Authority:
Environmental Protection Act, Part V, Section 27, and Part II, Section 9
Ontario Regulation 347, General – Waste Management Regulation
Ontario Regulation 346, General – Air Pollution
Ontario Regulation 512/95

Responsible Director:
Director, Standards Development Branch

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SYNOPSIS

This guideline applies to new publicly or privately-owned incinerator systems designed to burn municipal waste, as well as to the expansion or modification of existing incinerators. It may in the future be applied to the operation of existing incinerators which have not expanded or been modified.

This guideline was developed on the basis of "Maximum Achievable Control Technology," human health considerations and the approaches taken by other jurisdictions. For the purposes of this guideline, municipal waste means any waste, including solid fuel derived from waste, whether or not it is owned, controlled or managed by a municipality, except hazardous waste, liquid industrial waste or gaseous waste.

The requirements of this guideline supersede those of Guideline A-1 for municipal waste incinerators. However, it should be noted that this guideline does not apply to biomedical waste incinerators, sewage sludge incinerators or woodwaste incinerators. Those facilities are subject to the ministry's regulation requirements and any guideline developed specifically for those types of facilities.

The guideline will be applied through conditions on certificates of approval in accordance with the requirements of the *Environmental Protection Act*, Part V, Section 27, and Part II, Section 9.

The guideline reflects the installation of air pollution control systems, sets air emission limits for particulate matter, acid gases, metals and dioxins/furans and establishes requirements for the control, monitoring and performance testing of incineration systems.

Emission limits specified in this guideline will be reviewed and updated by the Ministry to reflect technology improvements and new health and environmental information.

1.0 INTRODUCTION

This guideline establishes minimum design and operating parameters, emission control systems and emission limits which will ensure control of emissions to the atmosphere from municipal waste incinerators of any size in Ontario.

This guideline applies to all new, expanded or modified incinerators burning municipal waste except those which burn sewage sludge or woodwaste either exclusively or in combination with conventional fossil fuel.

The requirements specified in this guideline are in addition to those in Ontario Regulation 346 (RRO 1990), General -- Air Pollution, including compliance with the point of impingement standards prescribed in Schedule 1 to that regulation and the concentration of organic matter limit in Section 12.

The limits in this guideline for dioxins and furans, cadmium, lead, mercury, particulate matter and acid gases are technology based, developed using the maximum achievable control technology (MACT) principle, or, in the case of the dioxin and furan limits, the Lowest Achievable Emission Rate principle. In all cases, the limits are below those that would be established based solely on protection of human health and the environment. The ministry will also ensure protection of human health and the environment by also using Ontario Regulation 346 and associated ministry policies containing point of impingement limits during the evaluation of new municipal waste incinerator proposals.

2.0 GUIDELINE LIMITS

New and upgraded municipal waste incinerators shall meet the emission limits in the stack as set out in Table 1, below:

TABLE 1		
Parameter	Emission Limit	Comments
particulate matter (PM)[1]	17 mg/Rm^3	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods
cadmium[2]	14 $\mu g/Rm^3$	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods
lead[2]	142 $\mu g/Rm^3$	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods
mercury[2]	20 $\mu g/Rm^3$	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods
dioxins and furans	80 pg/Rm^3 as ITEQ[3]	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods
hydrochloric acid (HCl)	18 ppmv (27 mg/Rm^3) or an HCl removal efficiency of not less than 95%	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emission monitoring system
sulphur dioxide (SO_2)[4]	21 ppmv (56 mg/Rm^3)	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the geometric average of 24 hours of data from a continuous emission monitoring system
nitrogen oxides (NO_x)[5]	110 ppmv	calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emission monitoring system
organic matter	100 ppmv undiluted (expressed as equivalent methane)	calculated as a 10 minute average at the outlet of the secondary chamber before dilution with any other gaseous stream, measured by a continuous emission monitoring system

Notes to Table 1

(1) For cement and lime kilns burning municipal waste, a site specific limit for particulate shall be established and incorporated into a certificate of approval. The site specific limit shall be a weighted average of the above limit for particulate from a municipal waste incinerator and the limit currently used for operation with conventional fuel. The weighting shall be based on the relative amounts of flue gas attributable to municipal waste combustion and conventional fuel combustion.

(2) For cement and lime kilns burning municipal waste, the cadmium, lead and mercury concentration requirements of this section shall apply unless the concentration of a specific heavy metal in the process raw materials (excluding fuel) fed to the kiln is such that the relevant limit would be exceeded. In such a case, site specific limits for metals may be established and incorporated into a certificate of approval.

(3) pg/Rm^3 as I-TEQ means picograms per reference cubic metre, at 25°C and 101.3 kilopascals pressure, of toxicity equivalents (calculated using the toxicity equivalence

factors recommended by the North Atlantic Treaty Organizations's Committee on Challenges to Modern Society [NATO/CCMS] in 1989 and adopted by Canada in 1990) to 2,3,7,8 tetrachloro dibenzo-*p*-dioxin; corrected to 11 percent oxygen and zero percent moisture (dry).

(4) For cement and lime kilns burning municipal waste, a site specific limit for SO_2 shall be established based on the concentration of SO_2 in the stack gases when burning conventional fuels and shall be incorporated into a certificate of approval.

(5) For cement and lime kiln operators wishing to seek approval to add municipal waste to their current fuel stream, a site specific NO_x emission limit will be set and written into the conditions of approval based on NO_x concentrations when burning conventional fuels. This will prevent any increase in NO_x emissions and may well see a decrease as the fuel stream is augmented. The ministry will continue to monitor the development of NO_x control technology worldwide and, as proven technology is developed, this guideline will be reviewed.

2.1 Other Industrial Processes Burning Municipal Waste

This guideline will apply to other industrial processes burning municipal waste which have not been specified above; however, where it can be demonstrated that the limits in this guideline are not consistent with the principle of maximum achievable control technology for an industrial process, industry may apply to the ministry for revised limits.

3.0 CONTROL AND MONITORING SYSTEMS

3.1 Continuous Emissions Monitoring

The incorporation of control and monitoring systems to indicate and confirm good combustion and compliance with the limits of this guideline, regulations and conditions of approval should be considered. Such systems should be capable of readily signifying any aspect of a substandard operation.

3.2 Continuous Monitoring Parameters

The Ministry encourages the installation of continuous monitors on all incinerators. Parameters that may be considered for continuous monitoring include:

- temperature(s)
- total hydrocarbons
- carbon monoxide
- residual oxygen
- carbon dioxide
- incinerator exhaust flue gas volume
- hydrogen chloride
- sulphur oxides
- nitrogen oxides
- opacity.

Continuous monitors should be located properly to measure the relevant parameters and should be equipped with recording devices for subsequent reference and analysis. The continuous monitors should correspond to the provisions of the Environment Canada document "Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation" (Report EPS 1/PG/7, September 1993) or some equivalent specification approved by the Director of the ministry's Environmental Assessment and Approvals Branch.

4.0 EMISSIONS TESTING

Within six months of start-up, all incinerator units shall determine compliance with the limits set out in Table 1 through source emissions testing performed in accordance with the methods and procedures documented in the Ontario Source Testing Code (Procedure A-1-1), under maximum operating feed rates for the combustor. Thereafter, source emissions tests to demonstrate performance shall be repeated at a frequency of at least once a year.

Where emissions problems occur with an operating combustor, the Director may require additional source emissions testing to be conducted by the operator.

In cases where the Ministry concludes that a proposed combustion system design may not be capable of consistently maintaining good combustion (see Section 7), as a condition of approval, the Ministry may require performance testing for additional emission parameters that are by-products of incomplete combustion, such as carbon monoxide, benzo(a)pyrene, biphenyl, naphthalene, formaldehyde, and odour.

Source emissions testing for dioxins and furans shall be conducted to determine emissions of all of the contaminants for which Toxic Equivalency Factors (TEFs) have been established by NATO/CCMS, and results expressed as I-TEQ using the NATO/CCMS TEFs. Compliance will be determined based on measured I-TEQ emission levels. Table 2 provides a listing of the contaminants used, and the TEFs assigned to each contaminant.

In determining I-TEQ emission levels, where the analytical results indicate that the amount of a particular isomer of dioxins and furans or dioxin-like polychlorinated biphenyls (PCBs), referenced in the attached Schedule A, is less than the detection limit reported by the laboratory analyzing the source emission testing samples the amount of dioxins and furans shall be reported as the toxic equivalent concentration (I-TEQ) by using the reported detection limit as the amount present for that isomer. The reported detection limits are to be determined by the laboratory at the time the source emission testing samples are analyzed based on analysis of appropriate replicate low level samples or blanks.

If the annual source emissions testing indicates that the concentration of dioxins and furans has remained consistently below 32 pg/Rm^3 as I-TEQ for five (5) consecutive years, then the source operator/owner may exclude dioxins and furans from the annual source emissions testing every second year as long as the concentration of dioxins and furans continues to remain below 32 pg/Rm^3 as I-TEQ.

Table 2 - Toxic Equivalency Factors (TEFs)

Congener	NATO/CCMS (1989)
PCDDs	
2,3,7,8-TCDD	**1**
1,2,3,7,8-PeCDD	**0.5**
1,2,3,4,7,8-HxCDD	**0.1**
1,2,3,7,8,9-HxCDD	**0.1**
1,2,3,6,7,8-HxCDD	**0.1**
1,2,3,4,6,7,8-HpCDD	**0.01**
1,2,3,4,6,7,8,9-OCDD	**0.001**
PCDFs	
2,3,7,8-TCDF	**0.1**
1,2,3,7,8-PeCDF	**0.05**
2,3,4,7,8-PeCDF	**0.5**
1,2,3,4,7,8-HxCDF	**0.1**
1,2,3,7,8,9-HxCDF	**0.1**
1,2,3,6,7,8-HxCDF	**0.1**
2,3,4,6,7,8-HxCDF	**0.1**
1,2,3,4,6,7,8-HpCDF	**0.01**
1,2,3,4,7,8,9-HpCDF	**0.01**
1,2,3,4,6,7,8,9-OCDF	**0.001**

5.0 REPORTING

5.1 Emission Limits Compliance Testing

A report on the emissions testing performed in accordance with the requirements under sub-section 4.1, should be forwarded to the ministry's local district office within 90 days of completion of the testing. The report should contain all of the test data and information as required by the Ontario Source Testing Code, plus estimated annual emission loadings for mercury and dioxins & furans for the preceding calendar year and details of how these were calculated from the test results. The report should also be made available to the public on request. The incinerator operator should also provide a plain-English summary report of the results of the performance tests for general public distribution.

5.2 Unscheduled Shutdown

The incinerator operator should telephone the Ministry's local district office within two business days of an occurrence of an unscheduled shutdown of the air pollution control system to report the occurrence. The incinerator operator should then, within 30 days of the occurrence, submit a written report to the Ministry's local district office setting out the reasons for the shutdown and the measures that have been taken to prevent a recurrence.

6.0 DESIGN AND OPERATION CONSIDERATIONS FOR MUNICIPAL WASTE INCINERATORS

The objective of this section is to provide guidance on the design and operation consistent with achieving good combustion conditions in municipal waste incinerators and proper disposal of the ash residue. Minimum design and operating parameters for incinerator temperature, residence time and combustion air distribution are recommended to provide guidance to proponents in designing an incineration system that will achieve high combustion efficiencies. However, it should be emphasized that these requirements are not intended to restrict design technology. The Ministry will consider alternative incineration systems for approval provided that they are designed and operated to achieve a high level of combustion efficiency.

The Ministry will evaluate the design and operating parameters of incinerators when reviewing an application for approval. Detailed engineering drawings, specifications and calculations to support the design and operating parameters are required for the evaluation.

6.1. Incineration Temperature

The minimum combustion temperature achieved in a municipal waste incinerator is critical to achieving high-efficiency combustion and destruction of organic materials.
The Ministry acknowledges that incineration temperatures in the combustion zone (see definition) of municipal waste incinerators will vary with the design. These temperatures are normally specified in an incinerator design and will generally be in the range of 1000°C to

ensure high-efficiency combustion and destruction. Incinerators should be capable of sustaining, on a continuous basis, an incineration temperature about 100 Celsius degrees greater than the operating temperature.

An auxiliary burner should be incorporated into the design to ensure that the minimum operation temperature is maintained:

- at start-up before the commencement of the incineration cycle;
- during shutdown until all combustion of waste has ceased; and
- when necessary during other phases of operation.

6.2 Combustion Gas Residence Time

The Ministry recognizes that there are municipal waste incinerators in operation throughout North America with a wide range of combustion gas residence times. A minimum residence time of **one second** in the combustion zone at the minimum combustion temperature specified in the design is generally considered adequate to provide high-efficiency incineration.

The residence time should be calculated from the point where most of the combustion has been completed and the incineration temperature has fully developed. If air is introduced downstream of the burner flame front, residence time should be calculated from the final air injection point.

(a) Multi-chamber Incinerators

In multi-chamber incinerators, the residence time should be calculated from the secondary burner(s) flame front. If air is introduced downstream of the burner flame front, residence time should be calculated from the final air injection point.

(b) Single-chamber Incinerators

Where the furnace is one continuous space, such as in "spreader stoker" and "single chamber mass burning" designs, the location of the complete combustion/fully developed temperature point should be determined by an overall design review, and may be significantly downstream of the final air injection point.

6.3 Combustion Air Distribution

Combustion air systems should be designed to control air distribution within the incinerator and the Ministry recognizes that these systems vary widely. Ideally, control systems should have the capability of adjusting the distribution of combustion air in order to provide the desired level of residual oxygen in the exhaust gases under all incinerator loading conditions.

6.4 Oxygen Availability

The lack of sufficient oxygen in the flue gases leaving the incinerator is an indicator of incomplete combustion and is a contributing factor to the discharge of volatile organic compounds. Incinerators should be designed and operated to ensure that sufficient residual oxygen in the flue gas exhaust has been provided to minimize the discharge of products of incomplete combustion during the entire incineration cycle. Also, a sufficient level of residual oxygen in the exhaust gases is critical with respect to meeting the total hydrocarbon limit of 100 ppmv in Section 12 of Ontario Regulation 346.

Incinerators and their air distribution systems will normally be designed and operated to provide an oxygen rich atmosphere in the range of 6% O_2 in the combustion zone.

6.5 Gas-Phase Turbulence and Mixing

The design of an incinerator should provide and the operation maintain a high degree of gas-phase turbulence and mixing in the combustion zone. This can usually be achieved through appropriately located/directed air jets, changes of flue gas flow direction, baffling, and constriction of cross-sectional flue gas flow area.

6.6 Range of Operation

Municipal waste incinerators should be designed to achieve the temperature, residence time, oxygen availability and turbulence conditions specified in their design over the entire expected range of values of the incinerator operating parameters, including:

- feed rate (including minimum and maximum rates);
- ultimate analysis, heating value, ash and moisture content of the waste;
- combustion air; and
- heat losses.

6.7 Continuous Operation of Air Pollution Control Systems

Air pollution control systems for incinerators shall be designed to operate on a continuous basis, as much as possible, whenever there is waste burning in the incinerator. The design of the system shall incorporate consideration of:

- the conditions which could lead to an unscheduled shutdown of the air pollution control system;
- means of ameliorating such conditions; and
- air pollution control bypassing which cannot be avoided.

The incinerator system controls shall be designed to ensure the shutdown of the incinerator immediately upon an unscheduled shutdown of the air pollution control system in a manner that will minimize air emissions. The control system shall also be designed to record pertinent information for subsequent reporting to the ministry's local district office and for an assessment of the reasons for the shutdown and potential measures to prevent a recurrence.

6.8 Ash Management and Organic Content of Ash

Under Ontario Regulation 347, fly ash from the incinerator's energy recovery and pollution control system must be handled separately from the burning zone's bottom ash. Fly ash must be tested for leachate toxicity if the operator wants to classify the ash as non-hazardous. The ministry's testing protocol for leachate toxicity is contained in Ontario Regulation 347 while the sampling procedure and results evaluation procedure is in the ministry's policy publication "Protocol for Sampling and Evaluating Fly Ash from Non-Hazardous Solid Waste Incineration Facilities".

Incinerator operators shall analyze bottom and fly ashes sent to disposal for leachate toxicity and ultimate analysis during performance tests or at the direction of the Director of the ministry's Environmental Assessment and Approvals Branch.

The incinerator operation shall be controlled such that the organic content of the bottom ash shall be minimized to the greatest degree possible. A maximum organic content of 5% is generally considered achievable by single chamber incinerators and 10% by multiple chamber incinerators.

6.9 Pressure Control and Emergency Exhaust

Incinerators should be designed to operate under negative pressure during all phases of operation. If an emergency exhaust is provided in the design, its location and method of operation should be specified.

7.0 APPROVAL OF INCINERATOR DESIGN AND OPERATING CRITERIA

Part 9 of the *Environmental Protection Act*, requires that a proponent of a municipal waste incinerator apply to the Ministry of Environment for approval to install and operate an incinerator. If the application is approved, the ministry will issue a certificate of approval for the incinerator which will incorporate emission limits, and monitoring and operating requirements, based on the limits and criteria set out in this guideline. The certificate may also incorporate other requirements specific to the location and the nature of the application for approval.

> *The design and operating criteria discussed in this guideline are provided as a guide to achieving good combustion. Other design and operating criteria may be proposed for approval but the proponent will be required to show that the alternative criteria have been successfully used elsewhere in the design and operation of a municipal waste incinerator, and have achieved good combustion over the range of feed rate conditions that will be encountered.*

The ministry will evaluate the design and operating parameters of incinerators when reviewing an application for approval. Detailed engineering drawings, specifications and calculations to support the design and operating parameters are required for the evaluation.

8.0 DEFINITIONS

Burner Flame Front:
The visible luminous front zone of the flame, formed by the burner, in which intense localized gas phase combustion occurs.

Combustion Air:
The air supplied to the incinerator for the burning of the waste and/or the fuel.

Feed Rate:
The weight of waste introduced or fed into the incinerator per unit time.

Gas-Phase Turbulence:
Turbulence in the combustion gases, denoting an irregular fluctuation (i.e. mixing and eddying) superimposed on the main stream. Good mixing of the products of incomplete combustion (primarily carbon monoxide and hydrocarbons) and of the combustion air is promoted by a highly turbulent flow of the gases.

Negative Pressure:
A pressure that is less than ambient pressure.

Operating Parameters:
The variables of the incinerator process and waste stream used to control the operation of the incinerator. These include: the waste feed rate, composition, and heating value; combustion air feed rate(s); and heat production and losses.

Reference flue gas conditions:
Reference flue gas conditions are defined as follows:

- Temperature 25 °C
- Pressure 101.3 kPa
- Oxygen content 11%
- Water content nil (dry conditions)

9.0 ABBREVIATIONS

CCME	Canadian Council of Ministers of the Environment
CCMS	[NATO] Committee on Challenges to Modern Society
HCl	hydrogen chloride or hydrochloric acid
I-TEQ	international toxicity equivalents to 2,3,7,8 tetrachloro dibenzo-*p*-dioxin (calculated using the toxicity equivalence factors recommended by the NATO CCMS in 1989 and adopted by Canada in 1990)
kPa	kilopascals
mg/Rm^3	milligrams per reference cubic metre
NATO	North Atlantic Treaty Organization
O_2	oxygen
pg/Rm^3	picograms per reference cubic metre
ppmv	parts per million by volume
R	reference conditions
SO_2	sulphur dioxide
$\mu g/Rm^3$	micrograms per reference cubic metre